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Impact of Natural Additives with a Low-Sodium Salting Process on the Quality of the Salted Raya Fish (*Alestes dentex*)

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ABSTRACT

One of the fish captured from Lake Nasser in Aswan Governorate of Egypt is the Raya fish, which is remarkably used to make Moloha (a heavy salted fish). The purpose of this study was to examine the Raya fish subjected to a salting process using low-sodium salt, either with or without the addition of natural additives, viz. turmeric, ginger, yeast, and lemon juice. The findings demonstrated that the addition of ginger or turmeric to low-sodium salt treatment (F5, F6) led to a notable increase in the wet weight content of fat (7.30% & 8.30%) and protein (17.47% & 17.30%), respectively. The salt content decreased in all treatments after being treated with low-sodium salt, according to the results, falling between 4.08% and 4.86% in comparison with treatment F1 (6.98%). The greatest significant reductions in TBARS values (1.11 & 1.04mg MDA/kg sample), TVB-N values (41.84 & 40.02mg/ 100g), and total bacterial counts (4.27 & 4.29 log CFU/g) were observed in treatments F5 & F6, respectively. Comparing treatments F5 and F6 to the others, the former displayed the highest sensory evaluation scores.

INTRODUCTION

Salting is one of the oldest and most cost-effective techniques for preserving fish and extending its shelf life. This method meets consumer demand worldwide **(Hafez *et al*., 2019)**. Moloha is a type of salted fish that is particularly favored by many people in Upper Egypt, especially those with lower incomes, due to its affordability. Moreover, it is a heavily salted fish product, and the high salt content is crucial for prolonging its shelf life and preventing spoilage and microbial contamination, especially in hot climate.

Two small freshwater fish species are used to make Saedy moloha: *Leptocypris niloticus* (commonly known as the Bebee-Morgan Nili) and *Alestes baremoze* (known as the pebbly fish). The manufacturing process involves mixing the fish with sodium chloride at a ratio of 1:4 to 1:9 and allowing the mixture to ferment naturally for approximately 150 to 250 days **(Youssef *et al*., 2003)**.

However, the increased consumption of sodium chloride has raised concerns in recent years due to its association with serious health issues, particularly for the elderly and individuals with high blood pressure. Additionally, elevated salt levels can negatively impact the texture and overall the acceptability of the salted product **(Hafez *et al*., 2019; Barcenilla *et al*., 2022)**.

Countless countries have explored effective ways to reduce dietary salt intake **(FDA, 2010)**. Since 75% of dietary salt comes from processed foods, the food industry should focus on lowering the salt content in these products to address public health concerns such as high blood pressure and stomach cancer **(Appel & Anderson, 2010; Graudal *et al*., 2012)**.

In contrast, the current demand for salted fish is primarily driven by sensory enhancement rather than preservation **(Mujaffar & Sankat, 2005**). Thus, it can be said that the purpose of producing salted fish is not only to create a shelf-stable product with low moisture and high salt content but also to promote important sensory changes. At low salt concentrations, high water-protein interaction leads to maximum muscle swelling. However, at higher salt concentrations, strong protein-protein bonds may develop, resulting in dehydration and increased fat oxidation **(Chan *et al*., 2023)**.

The functionalities of salting include ensuring microbiological safety and improving sensory attributes, mainly color, taste (saltiness), and texture, as well as acting as a binding and emulsifying agent **(Est´evez *et al*., 2021)**.

Seafood processors have significant opportunities to further reduce the salt content in various fish products by implementing effective strategies. These strategies can involve not only reducing the amount of sodium chloride (NaCl) used but also substituting it with other salts and additives, or utilizing different methods and technologies that do not negatively impact consumer acceptance **(Pedro & Nunes, 2019)**.

Generally, the main approaches for lowering sodium content in processed seafood products include: (1) decreasing the amount of added sodium chloride (NaCl); (2) replacing all or part of the NaCl with other chloride salts such as potassium (KCl), calcium ($CaCl_2$), and magnesium ($MgCl_2$), or by using flavoring agents, binding agents, preservatives, and more; (3) developing new processing techniques or modifying existing processes; and (4) combining any of these approaches **(Rybicka *et al*., 2022)**.

Salted fish processors need to engage in collaborative efforts to produce low-salt products in order to mitigate serious health risks. However, salting and fermentation processes conducted under uncontrolled conditions can lead to foodborne illnesses due to microbial activity. Consequently, the aim of this study was to implement a technological method that utilizes a low percentage of salts along with natural additives to produce whole low-salted Raya fish. In addition, the current investigation was conducted to evaluate the quality of these low-salted products in comparison with the traditional salted fish.

MATERIALS AND METHODS

1. Material

1.1. Fish sample collection

Almost one hundred kilograms of fresh Raya fish (*Alestes dentex*) from the Alestidae family were collected during December, 2024 from Aswan port, Egypt (Figs.1, 2). The average of the length and weight of the fish ranged from 30.5 to 36cm and 252 to 281g, respectively. All fish samples were transported with ice (1:2 w:w) to the laboratory of the Faculty of Fisheries and Fisheries Technology, Aswan University, Egypt.

Fig. 1. Raya (*Alestes Dentex*) fish from Nasser Lake

Kingdom: Animalia
Phylum : Chordata
Subphylum : Vertebrata **Lamarck 1801**
Superclass : Gnathostomata
Superclass : Actinopterygii
Class : Actinopteri
Subclass : Neopterygii
Superorder: Characiphysae
Order : Characiformes
Family : Alestidae
Genus : Alestes
Species: *Alestes dentex*

Fig. 2. Scientific classification of Raya fish (*Alestes dentex*) in Nasser Lake

1.2. Chemicals, salts and natural additives

The common salt (Sodium Chloride) was purchased from the Egyptian El-Nasr Saline’s Company through the Aswan Market. Food-grade potassium chloride (KCl) salt was obtained from Naturejam manufacturer. Instant dry yeast was from Cook's. Lemon was purchased from the local market to prepare 1% lemon juice. Powdered ginger and turmeric were from spice shops. Chemicals such as HCl, NaOH, boric acid, glacial acetic acid, methanol, etc. were purchased from Dia chem Chemicals. All chemicals used in this study were analytical grade.

1.3. Media

Peptone water (DM185D, MAST, UK), plate count agar (Lab M, UK), Plate Count Agar (Oxoid, CM463) and Potato Dextrose Agar medium (lab M, UK) were used in the present study.

1.4. Other materials

Plastic bags (PE), transparent stretch wrap film, aluminum foil (AL–F) were purchased from the local market in Aswan Governorate, Egypt.

2. Methods

2.1. Preparation of salted Raya fish

The whole fish samples were divided into six treatments. Each treatment was subjected to dry salting with 12% salt (w/w) and/ or without natural additives according to the following:

F1- 12% salt (100% NaCl)

F2- 12% salt (NaCl 70% + 30% KCl)

F3- 12% salt (NaCl 70% + 30% KCl) + 1% yeast

F4- 12% salt (NaCl 70% + 30% KCl) + 1% lemon juice

F5- 12% salt (NaCl 70% + 30% KCl) + 1% ginger

F6- 12% salt (NaCl 70% + 30% KCl) + 1% turmeric

Each treatment was packed into two polyethylene bags and wrapped with stretch wrap film and Al-F to close well to prevent air. After the specified period (14 days) at ambient temperature (25±2°C), the samples were opened to conduct the following examinations.

2.2. Biochemical analysis

Based on standard procedures of **AOAC (2012)**, the moisture content was estimated by determining the weight lost during the drying process of 5g of the minced sample at 105°C for 6h. The protein content was determined through applying the Kjeldahl method (**ISO 5983-2: 2009**). The total lipids (TL) were extracted by following the **Bligh and Dyer (1959)** method, using a solvent composed of methanol/chloroform/0.88% KCl (at 1/1/0.5, v/v/v). The ash and sodium chloride (NaCl) contents were determined according to **AOAC (2012)**. The carbohydrate was computed by the difference.

The **pH value** was determined by homogenization of a flesh sample (10 g) into 90ml distilled water and using a calibrated pH meter (OHAUS STARTER 2100 Bench pH meter, OHAUS Instruments, USA).

Thiobarbituric Acid Reactive Substances (TBARS) value was determined according to **Pearson (1976)**, where the distilled samples and blank with TBARS reagent were heated over the water bath for 35min. After cooling, the optical density (OD) of the sample against the blank was read through a spectrophotometer (T60 UV-Visible Spectrophotometer) at 538 nm. The TBARS value was computed using the following equation:

$$\text{TBARS } (mg \text{ Malondialdehyde/kg sample}) \ value = \text{OD}_{\text{at 538 nm}} \times 7.8.$$

Total volatile basic nitrogen (TVB-N) content was determined by following the modified distillation method of **Antonacopoulos (1968)**. After the neutralization of the distillated sample containing Tashiro's indicator (composed of a solution of 0.1% methylene blue and 0.03% methyl red in ethanol or in methanol) with 0.1 N HCl, the TVBN value was estimated as follows:

$$\text{TVBN } (mg/100g) \text{ value} = (ml \text{ 0.1 N HCl} \times 1.4 \times 100) \text{ / weight of the sample.}$$

2.3. Microbiological analysis

All samples were examined clinically to detect the presence of any abnormality and parasites according to the methods outlined in the study of **Noga (2010)**.

Dilutions for microbiological analysis were prepared by homogenizing 10g of each salted whole Raya fish under treatment in 90ml of 0.1% peptone water (Oxoid) using stomacher lab–blender 400 (Seward Medical, London, U.K) for 30s at a normal speed. Decimal dilutions were prepared using sterile 0.1% peptone water solution. 1 ml of the homogenate was used for enumeration of microorganisms.

Total aerobic bacterial count was done by using pour plate and spread techniques as described in the Compendium of Methods for Microbiological Examination of Foods (**APHA, 2001**) and Food and Drug Administration (**FDA, 1998**). Plate Count Agar (Oxoid, CM463) was used as medium. Plates were incubated at 35°C for 48h. Bacterial populations were measured as Log CFU/g sample.

Yeasts and molds were enumerated on Potato Dextrose Agar medium (lab M, UK). The incubation period was 3-5 days at 25±2°C and plates containing 10-150 colonies were examined and expressed as Log CFU/g (**APHA, 2001**).

2.4. Sensory evaluation

After 14 days of salting and providing suitable conditions for all salted whole Raya fish treatments, an organoleptic test was conducted with 10 faculty members from the Faculty of Fisheries and Fish Technology, Aswan University. Each member of the panelists was asked to evaluate the appearance, taste, texture, flavor, color, odor, and overall acceptability of each treatment using a 9-point hedonic scale, where excellent equals 9 and poor/unacceptable equals 1 **(Muzaddadi, 2013)**. The score of each sensory attribute was expressed as the mean value.

2.5. Statistical analysis

All survey variables, including means, standard deviations (SD), and ANOVA one-way test analysis, received descriptive analysis using IBM SPSS Statistics 25 (IBM Corporation, New York, USA). A probability value ($P< 0.05$) was used to indicate differences for statistical significance.

RESULTS AND DISCUSSION

1. Chemical composition of whole salted Raya fish

The chemical composition of whole Raya fish that has been dry salted with sodium salt or low-sodium salt, with or without natural additives, is shown in Table (1). The results show that there are significant differences between the sample treated with sodium salt and the samples treated with low-sodium salt, with or without natural additives. The moisture content in the different treatments ranged between 62.27 and 69.37%, whereas the highest moisture content was found in treatment F3, to which yeast was added, and treatment F6 was the lowest content, to which turmeric was added. Additionally, the results demonstrate that the addition of ginger and turmeric, respectively, resulted in significantly higher protein percentages on a wet weight basis for the samples in treatments F5 and F6, at 17.47% and 17.30%, respectively. However, a slight significant effect of lowering the sodium level appeared in the samples of treatments F2, F3, and F4, which appeared to have significantly lower protein percentages at 15.13%, 15.35, and 15.20%, respectively. Carbohydrates, fat, and ash ranged from 2.05 to 6.77%, 6.1 to 8.28%, and 6.1 to 8.3%, respectively. The chemical composition of salted Raya fish, particularly the proportions of protein and fat in samples F5 and F6, seems to have been significantly impacted by the chemical composition of both ginger and turmeric.

Mohdaly *et al*. (2021) investigated moisture, protein, fat, carbohydrate, and ash of the Egyptian Moloha (*Hydrocynus vittatus*) and their values were 52.75%, 18.47%, 6.4%, 5.24%, and 17.13%, respective, which somewhat agree with the result of this study. In contrast, **Ahmed *et al*. (2020)** found that the moisture, protein, fat, and ash contents ranged between 32.68 and 48.73%, 21.88 and 31.50%, 3.11 and 12.78%, and 21.55 and 27.30%, respectively, for *Alestes* spp. Fesseikh. Combination of salt and spices can produce good quality products with satisfactory percentage of protein and fat (**Rahman *et al*., 2017**). In addition, **Kasozi *et al*. (2016)** found that the moisture, protein, and fat in the dry salted Pebbly fish (*Alestes baremoze*) ranged between 36.0 and 41.6%, 31.7 and 35.1%, and 12.9 and 16.6%, respectively. Similarly, **El Hag *et al*. (2012)** determined the composition of fresh *Alestes* spp. and found that moisture, protein, and fat were 70.41%, 17.45%, and 1.65%, respectively, while the dry salted with 25% salt for 12 days recorded values of 58.14%, 18.37%, and 1.48%, respectively.

Table 1. Proximate composition of whole low-salted Raya fish

Treatment	Moisture	Protein	Fat	Ash	Carbohydrate
F1	66.43±0.21[b]	15.97±0.40[b]	6.60±0.30[c]	6.10± 0.17[c]	4.90±0.35[ab]
F2	65.03±0.51[c]	15.13±0.25[c]	6.61±0.20[c]	6.87±0.25[b]	6.36±0.97[a]
F3	69.37±0.15[a]	15.35±0.38[c]	6.10±0.24[c]	7.13±0.31[b]	2.05±0.86[c]
F4	64.17±0.25[d]	15.20±0.30[c]	7.77±0.59[ab]	6.10±0.56[c]	6.77±1.63[a]
F5	64.87±0.35[cd]	17.47±0.12[a]	7.30±0.40[b]	6.10±0.56[c]	4.27±0.91[b]
F6	62.27±0.68[e]	17.30± 0.20[a]	8.30±0.15[a]	8.28± 0.16[a]	3.90±1.17[bc]

[a-f]Mean ± SD in the same column having different letters is significantly different at (*P*< *0.05*).

2. Physicochemical properties of whole salted Raya fish

Monitoring the physicochemical changes is crucial to controlling fat oxidation and reducing volatile nitrogenous compounds; whereas, the ripening the salted fish depends on the composition and concentration of salt used in addition to the chemical composition of the fish. The physicochemical properties of the whole Raya fish that were dry salted with sodium chloride salt or low-sodium salt, with or without natural additives, are shown in Figs. (3, 4, 5, and 6).

Fig. (3) indicates the pH values of whole salted Raya fish treatments. The results indicated that there are no significant differences (*P*< *0.05*) between the treatments investigated, as the pH values ranged between 6.57 and 6.77.

Mohdaly *et al*. (2021) measured the pH values of the Egyptian moloha and it was 6.69 which agrees with the results of the current study. **Edris *et al*. (2020)** evaluated the pH value of moloha collected from Aswan markets at 6.18, which is lower than that found in the present research, due to the effect of the heavy salting process. The results of this study are consistent with those of **Kasozi *et al*. (2016)**, who found that the pH of the dry salted Pebbly fish (*Alestes baremoze*) ranged between 6.3 and 6.9. Likewise, after 12 days of dry salting with 25%, **El Hag *et al*. (2012)** found that the pH of dry salted *Alestes* spp. was 6.9.

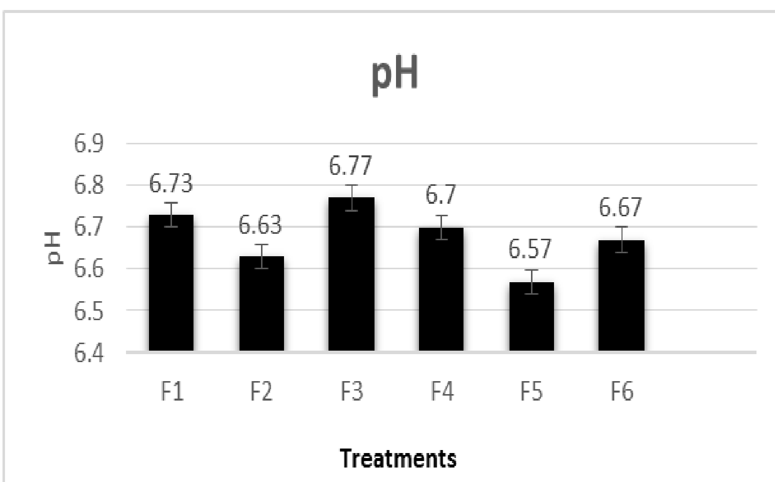

Fig. 3. pH values of whole low-salted Raya fish

The content of sodium chloride in salted Raya fish is shown in Fig. (4). According to the results, treatment F1 salted with sodium chloride had the highest percentage of sodium chloride (6.98%), whereas the remaining treatments had a significantly lower percentage (4.08–4.86%) because they were salted with a lower level of sodium chloride. The sodium chloride content was positively impacted by the addition of lemon juice, ginger, and yeast. Complete and effective salt infiltration into the fish muscle is dependent on many factors, including the fish thickness, temperature, purity of the salt, osmotic pressure, fish freshness, and the fat content **(Ingram & Kitchell, 1967)**.

Gomes *et al*. (2021) stated that replacing 50% of sodium chloride with potassium chloride did not affect pH compared to the control. **Mohdaly *et al*. (2021)** and **Edris *et al*. (2020)** determined that the salt content of moloha collected from the Egyptian markets ranged between 13.57% and 15.56%, respectively, which is extremely higher than the percentages detected in the present work, due to the effect of the heavy salting process. The results of this study differed from the results reported by **Kasozi *et al*. (2016)**, who found that the salt content of the dry salted Pebbly fish (*Alestes baremoze*) ranged between 13.1 and 14.9%.

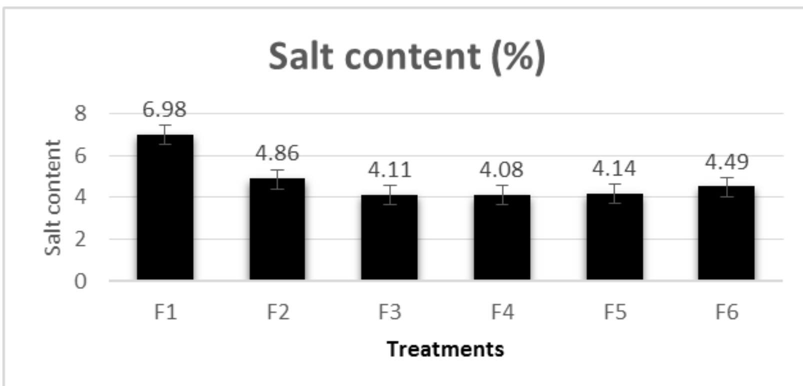

Fig. 4. Salt content in whole low-salted Raya fish

The amount of malondialdehyde (MDA) produced by the secondary oxidation of fish fat during the salting process is expressed by the TBARS value of whole salted Raya fish, as shown in Fig. (5). The results show that reducing the level of sodium used in salting slightly and significantly reduced the TBARS value from 1.54 to 1.27mg MDA/kg sample. The addition of turmeric and ginger showed a greater ability to reduce the TBARS value to 1.04 and 1.11mg MDA/kg sample due to containing antioxidant compounds.

In contrast to this study, **Mohdaly *et al*. (2021)** demonstrated the TBARS values of the Egyptian moloha and found that the sample had 5.11mg MDA/kg, which is higher than the 5mg MDA/kg in a high-quality product, whereas the consumption limits were 7–8 mg MDA/kg **(Cadun *et al*., 2005)**.

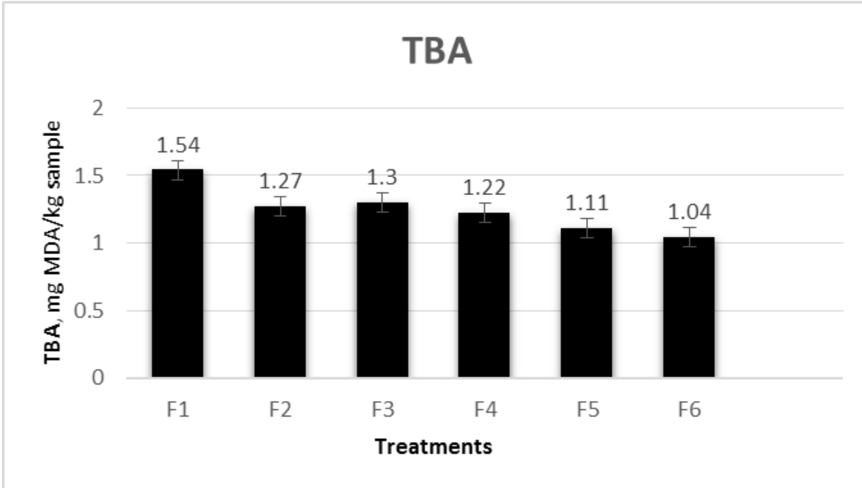

Fig. 5. TBARS value of whole low-salted Raya fish

As seen in Fig. (6), the salted whole Raya fish contain TVB-N, as an important indicator of protein breakdown that produces volatile substances like ammonia, amino bases, etc. The findings indicate that reducing the level of sodium used in salting significantly reduced the TVB-N content from 61.38mg/ 100g in treatment F1 to 52.96mg/ 100g in treatment F2. The addition of ginger and turmeric seemed to lower the TVB-N content to 40.02 and 41.84mg/ 100g, respectively.

Mohdaly *et al*. (2021), in their study, addressed the TVB-N values of the Egyptian moloha and found that the sample had 125.42mg/ 100g. Additionally, **Roy *et al*. (2014)** noted a high TVB-N in Telesech, an Indian fermented fish, at 210.9mg/ 100g, while **Anihouvi *et al*. (2012)** stated that TVB-N values of the fermented cassava fish for Lanhouin production ranged from 264 to 389mg/ 100g. The activity of endogenous and microbial proteolytic enzymes may be the cause of high TVB-N values, which breakdown protein into volatile nitrogenous compounds.

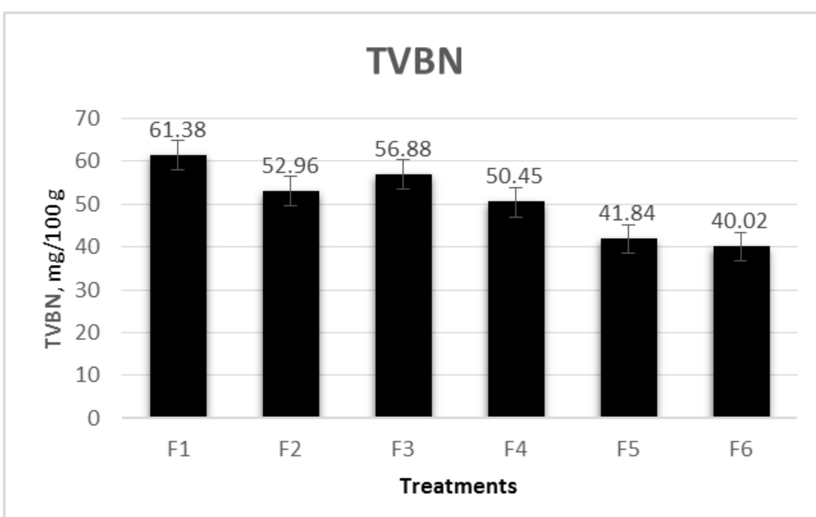

Fig. 6. TVB-N value of whole low-salted Raya fish

The study's physicochemical results would help maintain the protein ripening process while lowering the production of TVB-N content and reducing fat oxidation, all of which contribute to the creation of a healthy product with low sodium content.

3. Microbial loads

All samples are highly free from any clinical abnormality and parasite infestation, either encysted metacercaria in muscles or larvae. The spoiling caused by bacteria and fungi has an important contribution to the safety and quality of fisheries products. They cause undesirable favor and taste changes in salted fish. The results for the total load of bacteria, yeast, and mold counts in the salted whole Raya fish are displayed in Table (2). The results indicate that lowering the sodium level in treatment F2 caused a marginally significant increase in the total bacterial count (4.66 log CFU/g) compared to sample F1 (4.37 log CFU/g) as a result of the decrease in salt content in treatment F2. In contrast, it appeared that lowering the sodium level while adding ginger and turmeric caused a slight significant decrease in the total bacterial count in treatment F5 and F6, which were 4.27 and 4.29 log CFU/g, while adding both yeast and lemon juice in treatments F3 and F4 maintained the bacterial count level almost identical to treatment F1. The results also indicate that no colonies of yeast or mold appeared in all treatments of salted whole Raya fish, except for treatment F3, to which yeast was added, which contained 3.83 log CFU/g. These results demonstrate the quality of whole salted Raya fish is due to its compliance with the permissible microbial load (less than 7 log CFU/g) in salted fish according to the Egyptian standard specifications **(EOS, 2005)**. These findings could be related to the freshness of fish used in the production, the good quality of the ingredients, and the sanitary conditions applied during preparation, processing, and handling the products.

Mohdaly *et al*. (2021) examined the total bacterial count and yeasts and molds count of the Egyptian moloha and found that the sample had 4.58 log CFU/g, and 1.77 log CFU/g, respectively. **Edris *et al*. (2020)** elucidated that the aerobic plate count of moloha collected from Aswan markets was 3.53 log CFU/g, which is less compared to the value recorded in the current study, due to following heavy salting process. Furthermore, **Mustafa (2019)** stated that the total bacterial count of salted fermented fish (Hout-Kasef), a traditional salted fish from Saudi Arabia ranged from 2.81 to 4.72 log CFU/g.

Table 2. Microbiological counts (log CFU/g) of whole low-salted Raya fish

Treatment	F1	F2	F3	F4	F5	F6
Total bacterial counts	4.37±0.11^{ab}	4.66 ± 0.03^{a}	4.41 ± 0.08^{ab}	4.34±0.03^{ab}	4.27±0.13^{b}	4.29 ± 0.37^{b}
Yeast and mold counts	ND	ND	3.83±0.70	ND	ND	ND

$^{a-b}$Means with a different letter in the same row are statistically significant P<0.05.

4. Organoleptic properties

The average sensory evaluation scores for the whole salted Raya fish treatments are displayed in Table (3) and include appearance, color, taste, texture, flavor, and overall acceptability. According to the findings, the whole salted Raya fish treatments have average sensory evaluation scores that range roughly from very like to extremely like. Although there was a discernible reduction in the salty taste, lowering the sodium level in treatment F2 had no discernible effect on the average sensory evaluation scores from treatment F1. On the contrary, reducing the sodium level with the addition of ginger and turmeric in treatments F5 and F6 significantly increased the sensory evaluation scores and acceptability of the treatments, while adding lemon sticks slightly significantly reduced the acceptability of treatment F4, whereas adding yeast in treatment F3 showed the lowest average for the sensory evaluation scores, especially taste, flavor, and color.

Gomes *et al*. (2021) stated that replacing 25-50% of sodium chloride with potassium chloride improved the sensory properties, where it reduces fishy odor and undesirable off-odor, and this effect can be markedly higher in the presence of natural additives like turmeric and ginger, due to their antioxidant nature. Consistent with the present study, it was found that the color profile of the fermented Thai fish remained unaffected when 25-50% of sodium was replaced with KCl (**Jittrepotch *et al*., 2015, 2020**).

Table 3. Sensory evaluation of whole low-salted Raya fish

Parameters	F1	F2	F3	F4	F5	F6
Appearance	$8.2{\pm}0.13^{ab}$	$8.2\ {\pm}0.20^{ab}$	7.9 ± 0.22^{c}	$8.1{\pm}0.27^{ab}$	$8.3{\pm}0.14^{a}$	$8.4{\pm}0.11^{a}$
Taste	$8.2{\pm}0.17^{b}$	$8.2\ {\pm}0.14^{b}$	$7.9{\pm}0.13^{b}$	$8.0{\pm}0.19^{b}$	$8.5{\pm}0.18^{a}$	$8.6{\pm}0.12^{a}$
Texture	$8.0{\pm}0.24^{a}$	$8.1{\pm}0.18^{a}$	$8.0{\pm}0.10^{a}$	$7.9{\pm}0.22^{a}$	$8.1{\pm}0.12^{a}$	$8.2{\pm}0.10^{a}$
Color	$8.2{\pm}0.22^{b}$	$8.2\ {\pm}0.10^{b}$	$7.9{\pm}0.18^{c}$	$8.0{\pm}0.11^{bc}$	$8.2{\pm}0.11^{b}$	$8.7{\pm}0.14^{a}$
Flavor	$8.2 \pm .14^{bc}$	$8.1{\pm}0.20^{bcd}$	$7.8{\pm}0.15^{d}$	$7.9{\pm}0.17^{cd}$	$8.4\ {\pm}0.24^{ab}$	$8.7{\pm}0.22^{a}$
Overall acceptability	$8.1{\pm}0.27^{abc}$	$8.1{\pm}0.90^{abc}$	$7.9{\pm}0.17^{c}$	$8.0{\pm}0.13^{bc}$	$8.3{\pm}0.17^{ab}$	$8.4{\pm}0.17^{a}$

$^{a\text{-}d}$Means with a different letter in the same row are statistically significant $P < 0.05$.

CONCLUSION

This study offered a substitute that enhances the production of whole Raya fish that are highly salted, exposing consumers to non-communicable health risks like heart disease and high blood pressure. This study also sought to investigate the effect of using low-sodium salt with or without natural additives in salting whole Raya fish. Even though the salt content of whole salted Raya fish meat was reduced to less than 5%, it seemed that the use of low-sodium salt at a rate of 12% (70% NaCl + 30% KCl) with the addition of 1% turmeric or ginger improved the sensory properties in terms of appearance, color, taste, and texture. It also controlled the fat oxidation and protein decomposition and maintained the microbial quality.

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